

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
14 April 2005 (14.04.2005)

PCT

(10) International Publication Number  
WO 2005/033509 A1

(51) International Patent Classification<sup>7</sup>: F04B 35/04, 17/04

(21) International Application Number:  
PCT/KR2003/002054

(22) International Filing Date: 6 October 2003 (06.10.2003)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant (for all designated States except US): LG ELECTRONICS INC. [KR/KR]; 20, Yoido-Dong, Youngdungpo-Gu, Seoul 150-010 (KR).

(72) Inventor; and

(75) Inventor/Applicant (for US only): HYEON, Seong-Yeol [KR/KR]; Jugong Apt. 209-302, Shinwul-Dong, Changwon, Gyungangnam-Do 641-060 (KR).

(74) Agent: PARK, Jang-Won; Jewoo Bldg. 5th Floor, 200, Nonhyun-Dong, Gangnam-Gu, Seoul 135-010 (KR).

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

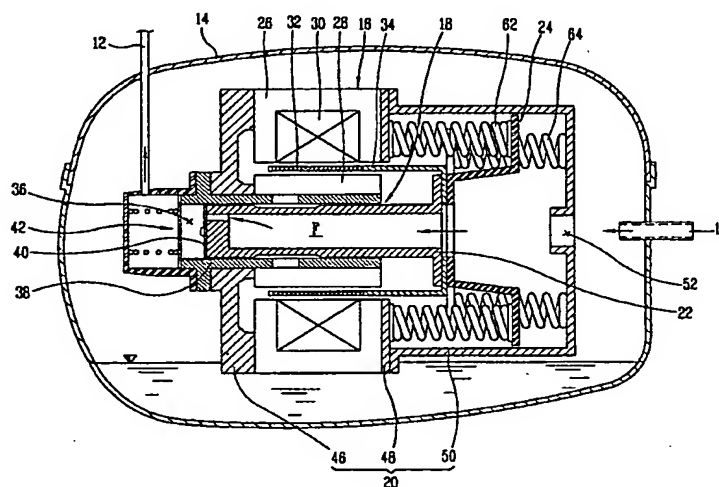
(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: RECIPROCATING COMPRESSOR



(57) Abstract: A reciprocating compressor includes a driving unit (16) having an outer stator (26) and an inner stator disposed at a predetermined air gap there between, and a moving member positioned between the outer stator (26) and the inner stator (28) and linearly and reciprocally moved; a compression unit (18) having a cylinder (38) fixed at an inner circumferential surface of the inner stator (28) and a piston (22) linearly moved in the cylinder (38) by being connected to the moving member; a support portion (20) supporting the compression unit (18) and the driving unit (16); and a resonant spring unit positioned (24) at a rear portion of the driving unit (16), disposed at the support portion (20), and inducing a resonant movement of the piston (22). Therefore, a resonant spring (62, 64) of the compressor can be moved horizontally and straight forwardly by reducing a torsion moment of the resonant spring (62, 64), a width of the compressor can be reduced, and a concentricity of a driving unit (16) and a compression unit can be maintained.

WO 2005/033509 A1

00/551625

8/pets  
JC20 Rec'd PCT/PTO 29 SEP 2003

1

**RECIPROCATING COMPRESSOR****TECHNICAL FIELD**

The present invention relates to a reciprocating compressor, and particularly to a reciprocating compressor that can be compact in size and having improved performance.

**BACKGROUND ART**

Figure 1 is a sectional view showing a reciprocating compressor in accordance with one example of a conventional art.

A conventional reciprocating compressor includes a close casing to which a suction pipe 102 and a discharge pipe 104 are connected respectively; a driving unit 108 disposed in the casing 106 and generating a reciprocal movement force; a compression unit 110 transmitted the reciprocal movement force generated at the driving unit 108 and compressing a fluid; a support portion 112 supporting the driving unit 108 and the compression unit 110.

The driving unit 108 includes an outer stator 116 fixed at the support portion 112 and having a winding coil 114 to which power is applied; an inner stator 118 disposed at an inner circumferential surface of the outer stator 116 with a predetermined air gap therebetween; a magnet 120 positioned at the air gap between the outer stator 116 and the inner stator 118 and linearly and reciprocally moved when power is applied to the winding coil 114; and a moving member 122 mounted to the magnet 120 at a same interval in a

circumferential direction and transmitting a linear movement of the magnet 120 to the piston 124 by being coupled with a piston 124 of the compression unit 110.

The compression unit 110 includes a piston 124 linearly and reciprocally moved by being coupled with the moving member 122; a cylinder 130, in which the piston 124 is slidably inserted, having a compression chamber; and a suction valve 132 installed at a front portion of the piston 124 to prevent the fluid introduced into the compression chamber from being flowed backwardly; a discharge valve assembly 134 installed at a front portion of the cylinder 130 to perform an open-and-shut action of a discharged fluid.

The support unit 112 includes a first frame 140 to which the inner stator 118 is fixed, mounted to an outer circumferential surface of the cylinder 130, and supporting one side surface of the outer stator 116; a second frame 142 supporting the other side surface of the outer stator 116; a third frame 144 coupled with the second frame 142 and receiving a resonant spring unit 146,

The resonant spring unit 146 for inducing a resonant movement of the piston 124, includes a first resonant spring 148 interposed between the first frame and one side surface of a connecting portion 152 between the moving member 122 and the piston 124, and providing an elastic force to the piston 124 when the piston 124 is rearwardly moved; and second resonant spring 150 interposed between the other side surface of the connecting portion 152 and the third frame 144, and providing an elastic force to the piston 124 when the piston 124 is forwardly moved in order to compress a fluid.

Herein, the first resonant spring 148 and the second resonant spring

150 are formed of a compression coil spring. The first resonant spring 148 has a bigger diameter than an outer diameter of the cylinder 130 and positioned at the outer circumferential surface of the cylinder 130, and the second resonant spring 150 is positioned at a rear portion of the compression unit 110.

5 In the convention reciprocating compressor, when power is applied to a winding coil 114, a flux is formed between the outer stator 115 and the inner stator, and thus the magnet 120 and the moving member 122 are linearly and reciprocally moved. While the piston 124 connected to the moving member 122 is linearly and reciprocally moved in the cylinder 130, a fluid is  
10 compressed.

At this time, when the piston 124 forwardly moves to compress a fluid, an elastic force of a second resonant spring 150 is provided to the piston 124, and when moving rearwardly, an elastic force of a first resonant spring 148 is provided to the piston 124.

15 However, in the conventional reciprocating compressor, the first resonant spring 148 is positioned in a space between an outer circumferential surface of the cylinder 130 and an inner circumferential surface of the inner stator 118. Accordingly, a width of a compressor should be big because a predetermined space should be secured to install the first resonant spring 148  
20 between the outer circumferential surface of the cylinder 130 and the inner stator 118.

Also, since the first and the second springs 148 and 150 are formed of a compression coil spring having a torsion moment, and are disposed at the both sides of a connection unit 152 between the moving member 122 and the

piston respectively, the torsion moment occurs while the first and the second springs 148 and 150 repeatedly compress and expand. Because of this, it is difficult for the piston 124 to keep its linear movement, so performance of a motor is deteriorated.

5           Figure 2 is a sectional view showing a reciprocating compressor for solving those problems according to another example of the conventional art.

          In a reciprocating compressor shown in Figure 2, a compression unit 110 is disposed at a front portion of a casing 106 and fixed at a first frame 162, and a driving unit 108 is disposed at a rear portion of the casing 106, and fixed  
10       at second and third frames 164 and 166. A moving member 122 of the driving unit 108 and a piston 124 are connected mechanically and a spring supporting member is disposed at a connection portion of the moving member 122 and the piston 124.

          Also, plural first resonant springs 172 are disposed between the first  
15       frame 162 and a front portion surface of the spring supporting member 176 at a predetermined interval in a circumferential direction. Plural second resonant springs 174 are disposed between a rear portion surface of the spring supporting member 176 and the second frame at a predetermined interval in a circumferential direction.

20           In the reciprocating compressor, a width of the compressor 110 can be reduced since the driving unit 108 and the compression unit 110 are positioned at front and rear portions of the casing 106 respectively and the first resonant spring 172 and the second resonant spring 174 are disposed at an outer circumferential portion of the compression 110. Also, since the plural

first and second resonant springs 172 and 174 are disposed in a circumferential direction, a torsion moment caused by repeated compression and expansion of the springs can be reduced.

However, in the reciprocating compressor according to the conventional art, the driving unit 108 generating a reciprocal movement force and the compression unit 110 transmitted the movement force from the driving unit 108 are disposed at the front portion and at rear portions of the compressor at a predetermined interval. Accordingly, it is difficult to adjust a concentricity of the driving unit 109 and the compression unit 110, and thus degrading of assembling is caused.

That is, even though a concentricity of the inner and outer stators 116 and 118 of the driving unit 108 has been adjusted, a concentricity of the driving unit 108 and the piston 124 of the compression unit 110 has to be adjusted again, and thus a difficulty of assembling is caused.

In addition, since the driving unit 108 and the compression unit 110 are disposed at the front and rear portions of the casing 106 respectively, the concentricity of the piston 124 is severely deviated even though the concentricity of the moving member 122 is little bit deviated during an operation of the compressor. This causes a collision of the cylinder 130 and the piston 124 and, accordingly, performance of the compressor is deteriorated.

#### **DISCLOSURE OF THE INVENTION**

Therefore, it is an object of the present invention to provide a

reciprocating compressor capable of moving a resonant spring horizontally and straight forwardly by reducing a torsion moment of the resonant spring, reducing a width of the compressor, and maintaining a concentricity of a driving unit and a compression unit.

5        To achieve the above objects, there is provided a reciprocating compressor including a driving unit having an outer stator and an inner stator disposed at a predetermined air gap therebetween, and a moving member positioned between the outer stator and the inner stator and linearly and reciprocally moved; a cylinder fixed at an inner circumferential surface of the  
10 inner stator; a compression unit coupled with the moving member and linearly and reciprocally moved in the cylinder; a support unit for supporting the compression unit and the driving unit; a resonant spring unit disposed at a rear portion of the driving unit, disposed at the support portion and inducing a resonant movement of the piston. .

15        The cylinder is fixed at the inner circumferential surface of the inner stator by a press-fit method.

      The support unit includes a first frame supporting an outer circumferential surface of the cylinder and one side surface of each of outer stator and inner stator; a second frame supporting the other side surface of  
20 the outer stator; a third frame coupled with the second frame and receiving the resonant spring unit.

      The resonant spring unit includes a spring support member mounted to a portion where the piston and moving member are connected; plural first resonant springs disposed between the second frame and one side surface of

the spring support member; plural second resonant springs disposed between the third frame and the other side surface of the spring support member.

The spring support member includes a coupling portion coupled with a portion where the moving member and the piston are connected, and disposed at a rear portion of the piston; a first support portion where the first resonant spring is supported; prolonged from an edge of the coupling portion at a predetermined interval in a circumferential direction; a second support portion where the second resonant spring is supported, disposed between the first support portions

10

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Figure 1 is a sectional view showing a reciprocating compressor in accordance with one example of the conventional art.

Figure 2 is a sectional view showing a reciprocating compressor in accordance with another example of the conventional art.

Figure 3 is a sectional view showing a reciprocating compressor in accordance with one embodiment of the present invention.

Figure 4 is a sectional view showing a state that an inner stator of a reciprocating compressor and a cylinder are coupled in accordance with the present invention.

Figure 5 is a sectional view taken along line V-V of Figure 4.

Figure 6 is a perspective view showing a resonant spring unit of a reciprocating compressor in accordance with the present invention.

Figure 7 is a side view showing a disposition state of resonant springs



of a reciprocating compressor in accordance with the present invention.

Figures 8 and 9 are partial sectional views showing a fixing state of a resonant spring in accordance with the present invention.

Figures 10 and 11 are front views showing a winding direction of a resonant spring of a reciprocating compressor in accordance with the present invention.

### **MODES FOR CARRYING OUT THE PREFERRED EMBODIMENTS**

A first embodiment of the present invention will now be described with reference to the accompanying drawings.

There can be a plurality of embodiments of the reciprocating compressor in accordance with the present invention, and a preferred embodiment will now be described.

Figure 3 is a sectional view of a reciprocating compressor according to the present invention.

The reciprocating compressor of the present invention includes a casing 14 to which a suction pipe 10 and a discharge pipe 12 are connected respectively; a driving unit 16 disposed in the casing 14 and generating a reciprocal movement force; a compression unit 18 disposed in the driving unit 16 and compressing a fluid by being transmitted the reciprocal movement force of the driving unit 16; a support unit 20 supporting the driving unit 16 and the compression unit 18; a resonant spring assembly 24 installed at the support unit 20 and inducing a resonant movement of the piston 22 by providing an elastic force to the piston 22 of the compression unit 18.

The driving unit 16 includes an outer stator 26 fixed at the support portion 20; an inner stator 28 disposed between itself and an inner circumferential surface of the outer stator 26 at a predetermined air gap; a winding coil 30 to which power is applied, disposed at one of the outer stator 28 and the inner stator 28; a magnet 32 installed at the air gap between the outer stator 26 and the inner stator 28, and linearly and reciprocally moved when power is applied to the winding coil 30; a moving member 34 at which the magnet 32 is fixed at a same interval in a circumferential direction, transmitting a linear movement of the magnet to the piston 22 by being coupled with the piston 22 of the compression unit 18.

The compression unit 18 includes a cylinder 38 fixed at the inner circumferential surface of the inner stator 28, and having a compression chamber 36 in which a fluid is compressed; a piston 22 linearly and movably inserted in the cylinder 38, coupled with the moving member 34, linearly moved when the moving member 32 is linearly moved, thereby compressing a fluid in the compression chamber 36; a suction valve 40 mounted to a front portion of the piston 122 to prevent the fluid introduced into the compression chamber from being flowed backwardly; a discharge valve assembly 42 disposed at a front portion of the cylinder 38 to perform an open-and-shut action of a discharged fluid.

Herein, as shown in Figures 4 and 5, the cylinder 38 is fixed at the inner circumferential surface of the inner stator 28 by a press-fit method or the like. That is, since the cylinder is directly fixed at the inner circumferential surface of the inner stator 28 and thus there is no gap therebetween, a width of the

compressor can be reduced.

The support unit 20 includes a first frame 46 mounted to the outer circumferential surface of the cylinder 38, and supporting one side surface of the outer stator 26; a second frame 48 supporting the other side surface of the  
5 outer stator 26; a third frame 50 coupled with the second frame 48 and receiving a resonant spring unit 24.

In the first frame 46, an outer circumferential surface of the cylinder 38 is supported at the inner circumferential surface of the first frame 46 by the press-fit method or the like, one side surface of the inner stator 28 is  
10 supported at its inner side surface, and one side surface of the outer stator 26 is supported at its outer side surface.

In the second frame 48, the other side surface of the outer stator 26 is supported at one side surface of the second frame 48. At the outer side surface of the second frame 48, the third frame 50 is fixed, and springs of the  
15 resonant spring unit 24 are supported.

In the cylindrical-shaped third frame 50, its one end is fixed at the second frame 48, and prolonged at a certain length toward the rear portion of the casing 14. A fluid passage 52 through which a fluid taken into the inlet 10 passes, is formed at the other end of the third frame 50, and springs of the  
20 resonant spring unit 24 are supported at its inner surface.

As shown in Figure 6, the resonant spring unit 24 includes a spring support member 60 mounted to a portion where the piston 22 and the moving member 34 are connected; a first resonant spring 62 disposed between the second frame 48 and one side surface of the spring support member 60, and

providing an elastic force to the piston 22 when the piston moves rearwardly; a second resonant spring 64 disposed between the inner surface of the third frame 50 and the other side surface of the spring support member 60 and providing an elastic force to the piston 22 when the piston moves forwardly.

5        Herein, the spring support member 60 includes a coupling portion 66 positioned at the rear portion of the piston 22 and fixed at a portion where the moving member 34 and the piston 22 are coupled; plural first support portions 68 prolonged from the edge of the coupling portion 66 at a certain interval in a circumferential direction and supporting the first resonant springs 62; second  
10       support portions 70 positioned between the first support portions 68, and supporting the second resonant spring 64.

      The disc-shaped coupling portion 66 has a passage 75 through which a fluid passes, at its center portion. The first support portion 68 is rearwardly prolonged from the edge of the coupling portion 66 at a certain length, and is  
15       outwardly bent at its end portion so as to install the first resonant springs 62. Plural first support portions 68 are formed at a certain interval in a circumferential direction of the coupling portion 66.

      The second support portions 70 are disposed between the first support portions 68 respectively, are radially prolonged from the edge of the coupling  
20       portion 66, and thus support the second resonant springs 64.

      In the first resonant spring 62, its both end portions are supported at the second frame 48 and at the first support portion 68 of the spring support member 60 respectively. In the second resonant spring 64, its both end portions are supported at the third frame 50 and at the second support portion

70 of the spring support member 60 respectively. Because of these, as shown in Figure 7, when the compressor is viewed from the side, the first resonant spring 62 and the second resonant spring 64 have an overlap section (L). Since the first resonant spring 62 and the second resonant spring 64 have the  
5 overlap section (L) in an axial direction of the compressor, a length in the axial direction of the compressor can be reduced.

In a different example of the spring support member 60, an overlap section of the first resonant spring 62 and the second resonant spring 64 can be extended more by forming the second support portion to be bent.

10 As shown in Figure 8, spring sheet portions 80 for supporting the first and the second resonant springs are formed at side surfaces of the first and the second support portions 68 and 70 respectively. The cylinder-shaped spring sheet portions 80 are prolonged from the side surfaces of the first and the second support portions 68 and 70 and support the first and the second  
15 resonant springs 62 and 64 respectively.

Figure 9 shows a special spring sheet member 82 mounted to each of the first and the second support portions 68 and 70 to support the first and the second resonant springs 62 and 64. The spring sheet member 82 consists of a fixing portion 84 inserted and fixed at a through hole 88 formed in each one  
20 of the first and the second resonant springs 62 and 64 by a press fit method or the like; and a sheet portion 86 prolonged from the fixing portion 84 and supporting the first and the second resonant springs 62 and 64.

The first and the second resonant springs 62 and 64 are formed of compression coil springs respectively, and offsetting torsion moments of each

other by having an opposite winding direction. As shown in Figure 10, that is, as shown in Figure 10, if the first resonant spring supported at the first support portion 68 is wound counterclockwise as the arrow P, the second resonant spring 64 disposed neighboring on the first resonant spring 62 is wound  
5 clockwise as the arrow Q.

As shown in Figure 11, the winding directions of the first resonant springs 62 disposed to face each other are different with each other, and the winding directions of the second resonant springs 64 disposed to face each other are different with each other, too. That is, if one first resonant spring 62  
10 is wound in a direction of the arrow S, the other neighboring first resonant spring 62 is wound in a direction of the arrow T. Also, if one second resonant spring 64 is wound in a direction of the arrow T, the other neighboring second resonant spring 64 is wound in a direction of the arrow S.

Operations and effects of the reciprocating compressor will now be  
15 described.

When power is applied to a winding coil 30, a flux is formed between an outer stator 26 and an inner stator 28. By the flux, a moving member 34 is linearly and reciprocally moved, and thus a piston 22 connected to the moving member 34 compresses and discharge a fluid introduced into a compression  
20 chamber while being moved linearly and reciprocally in a cylinder 34,

At this time, when the piston 22 moves forwardly to compress a fluid, an elastic force of a second resonant spring 62 is provided to the piston 22, and when the piston 22 moves rearwardly, an elastic force of a first resonant spring 64 is provided to the piston 22,

In the reciprocating compressor in accordance with the present invention, a width of the compressor can be reduced since a piston is directly fixed at the inner circumferential surface of the inner stator by a press-fit method or the like.

5           An interval in a longitudinal direction between a moving member and a piston can be minimized by positioning the piston in a moving member, whereby a concentricity of the moving member and the piston can be easily adjusted during assembling, and an attrition of the piston and the cylinder and a collision of the moving member and the outer/inner stators are prevented.

10           A length in an axial direction of the compressor can be reduced by disposing first and second resonant springs so as to overlap at a certain section.

          And, the plural first and second resonant springs are disposed in a circumferential direction, and their winding directions are arranged to be  
15       opposite with each other. Accordingly, since a torsion moment, which may occurs while each resonant spring compresses and expands, is prevented, a torsion of the piston and an attrition of portions being in contact with each resonant spring, are reduced, and thus reliability of a compressor can be improved.

20           It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

**CLAIMS**

1. A reciprocating compressor comprising:

a driving unit having an outer stator and an inner stator disposed at a  
5 predetermined air gap therebetween, and a moving member positioned  
between the outer stator and the inner stator and linearly and reciprocally  
moved;

a compression unit having a cylinder fixed at an inner circumferential  
surface of the inner stator, and a piston connected to the moving member and  
10 linearly moved in the cylinder;

a support unit supporting the compression unit and the driving unit; and

a resonant spring unit positioned at a rear portion of the driving unit,  
installed at the support unit and inducing a resonant movement of the piston.

15 2. The compressor of claim 1, wherein the cylinder is fixed at the  
inner circumferential surface of the inner stator by a press-fit method or the  
like.

3. The compressor of claim 1, wherein the support unit comprises:

20 a first frame supporting an outer circumferential surface of the cylinder,  
one side surface of the outer stator, and one side surface of the inner stator;  
a second frame supporting the other side surface of the outer stator;  
and

a third frame coupled with the second frame and receiving the resonant



spring unit.

4. The compressor of claim 3, wherein, in the first frame, an outer circumferential surface of the cylinder is fixed at the inner circumferential surface of the first frame by a press-fit method or the like, one side surface of the inner stator is supported at its inner side surface, and one side surface of the outer stator is supported at its outer side surface.

5. The compressor of claim 3, wherein the resonant spring unit comprising:

a spring support member mounted to a portion where the piston and the moving member are connected;

plural first resonant springs disposed between the second frame and one side surface of the spring support member; and

plural second resonant springs disposed between the third frame and the other side surface of the spring support member.

6. The compressor of claim 5, wherein the first resonant springs are arranged at a predetermined interval in a circumferential direction. and the second resonant springs are arranged between the first resonant springs respectively.

7. The compressor of claim 5, wherein the first resonant springs and the second resonant springs are disposed so as to overlap at a

predetermined section in an axial direction of the compressor

8. The compressor of claim 5, wherein the first and second springs are disposed to be parallel in the axial direction of the compressor.

5

9. The compressor of claim 5, wherein the first and the second resonant springs are formed of compression coil springs, and the first and the second resonant springs is mounted at spring support member so that an end portion of spring, a center of spring and a center of piston are arranged in line.

10

10. The compressor of claim 5, wherein the spring support member comprising:

a coupling portion coupled with a portion where the moving member and the piston are connected, and positioned at a rear portion of the piston;

15 a first support portion prolonged from the edge of the coupling portion at a predetermined interval in a circumferential direction and supporting the first resonant spring; and

a second support portion positioned between the first support portions and supporting the second resonant spring.

20

11. The compressor of claim 10, wherein the disc-shaped coupling portion has a passage through which a fluid passes, at its center portion, and fixed at portion where the piston and the moving member are connected.

12. The compressor of claim 10, wherein the first support portion is bent, rearwardly prolonged from the edge of the coupling portion, and formed so that its end portion is bent toward outside of the coupling portion to support the first resonant springs.

5

13. The compressor of claim 10, wherein the second support portion is radially prolonged from the edge of the coupling portion at a predetermined interval.

10

14. The compressor of claim 10, wherein the first support portion and the second support portion are alternatively formed in a circumferential direction of the coupling portion.

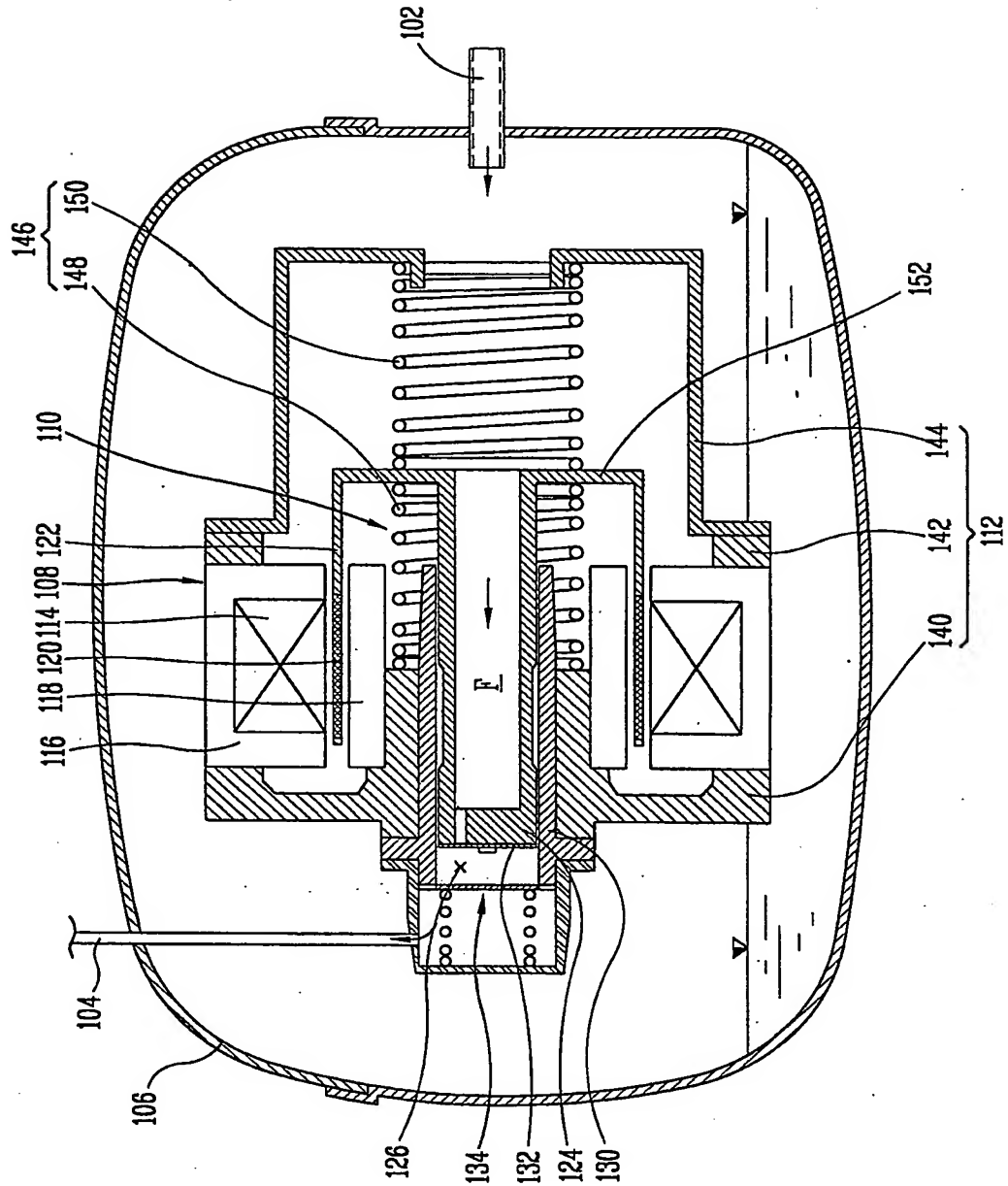
15

15. The compressor of claim 10, wherein spring sheet portions for fixing the first and the second resonant springs are formed at the first and the second support portions respectively.

20

16. The compressor of claim 15, wherein the spring seat portions respectively are formed as a cylindrical shape which is extended from respective sides of the first and second supporting portions, and the spring seat portions respectively have a hole formed therein.

FIG. 1



2/8

FIG. 2

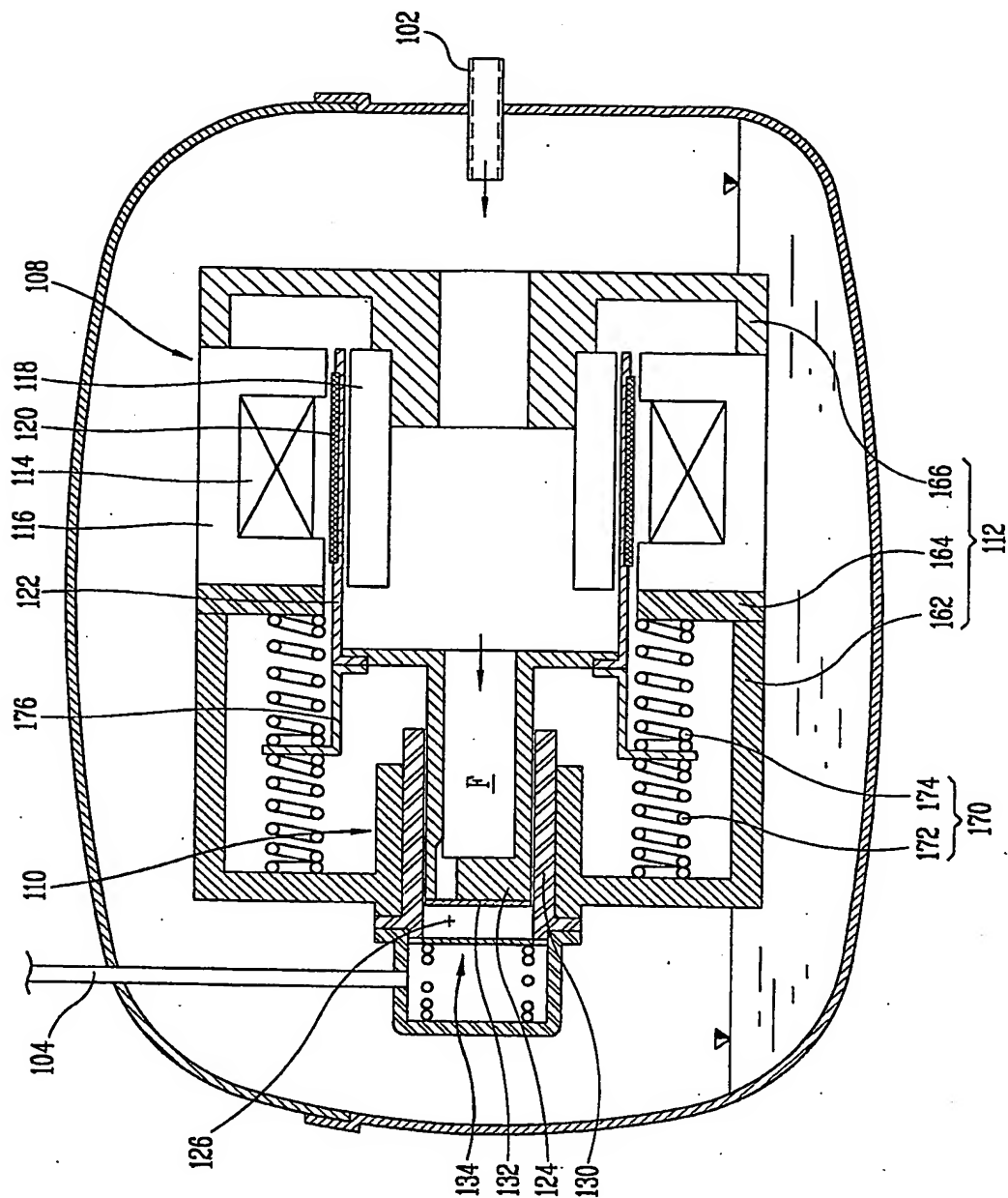
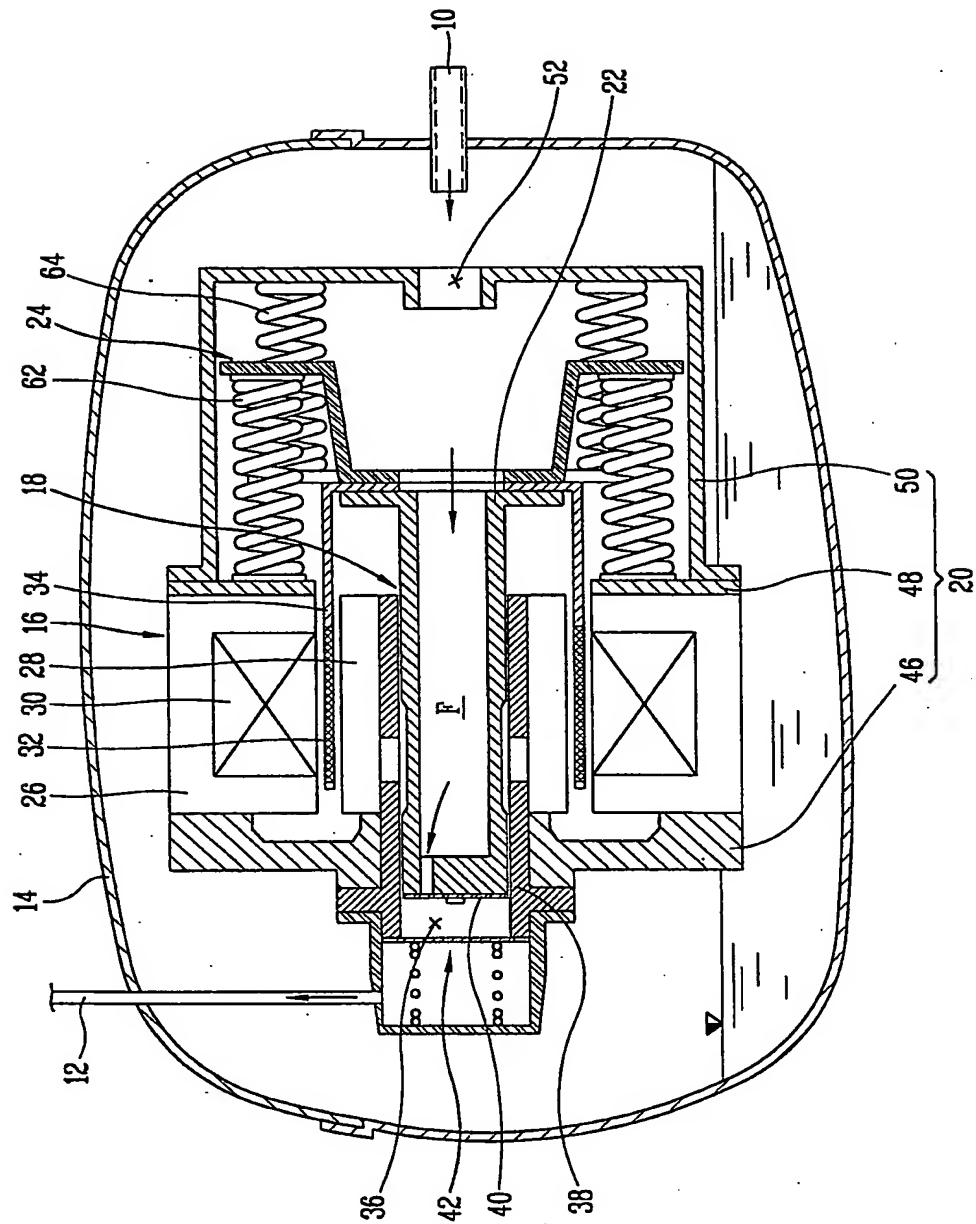


FIG. 3



4/8  
FIG. 4

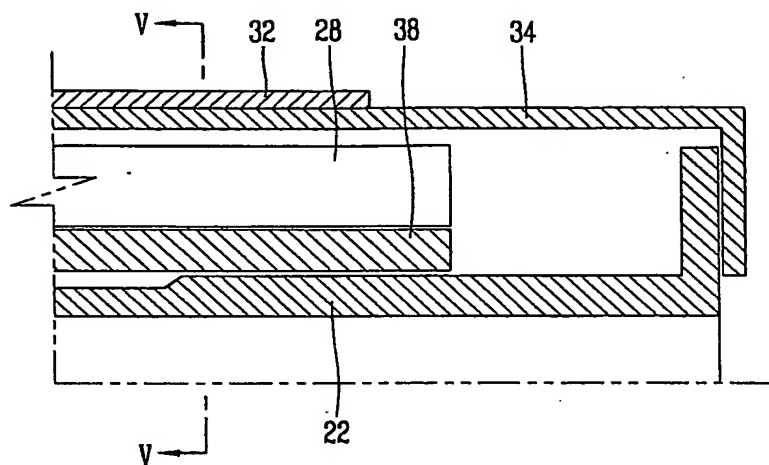
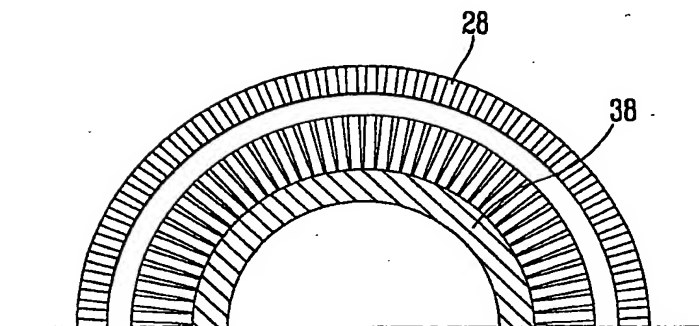


FIG. 5



5/8  
FIG. 6

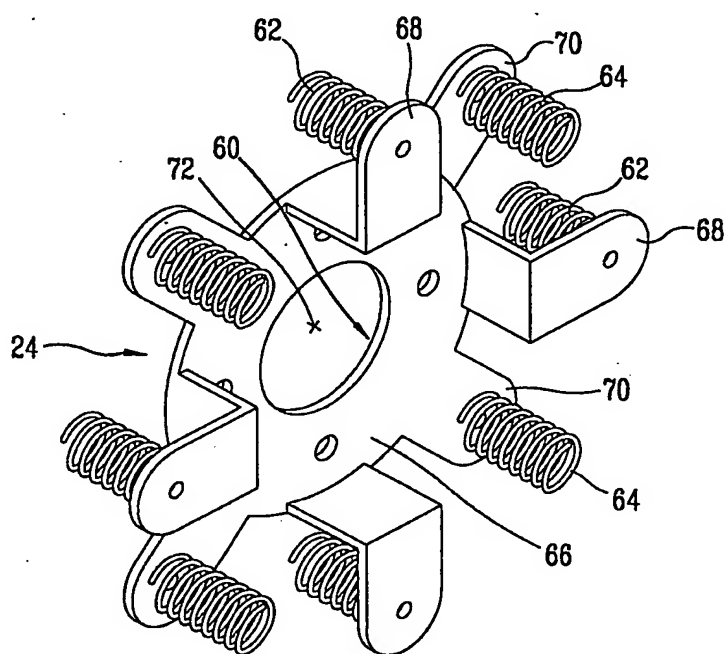
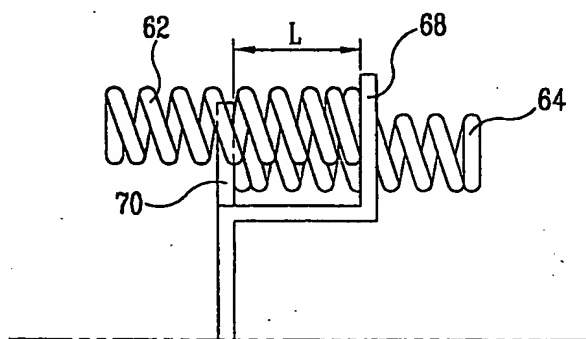


FIG. 7





6/8  
FIG. 8

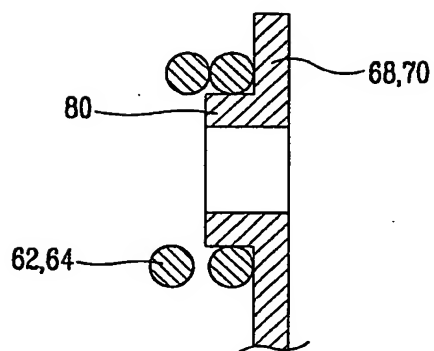
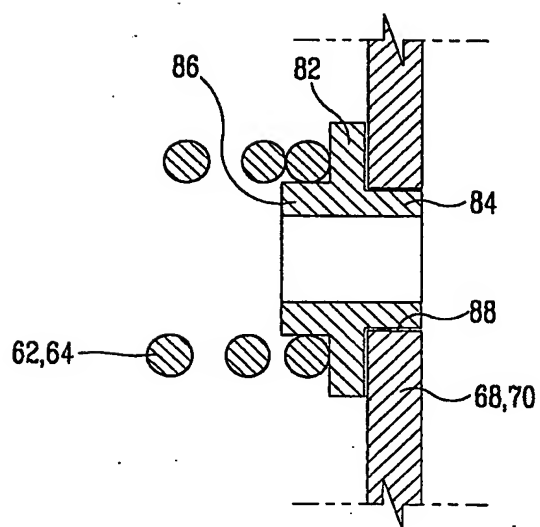
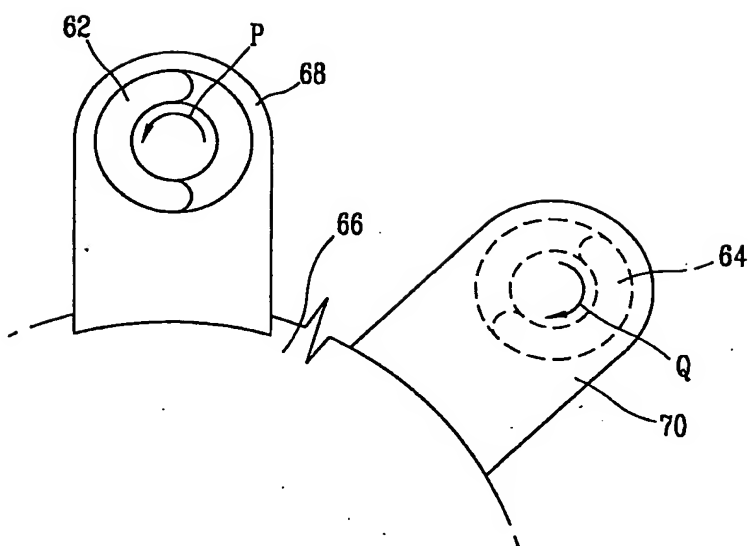


FIG. 9



7/8  
FIG. 10



8/8  
FIG. 11

